



# UK X-FEL Initiative

**Jim Clarke**

STFC Daresbury Laboratory & The Cockcroft Institute

XbFEL Face-2-face Meeting  
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# UK FEL Strategic Review

## Taken from the STFC Website:

- STFC is carrying out a review to determine a strategy for the UK's Provision of Free Electron Laser (FEL) facilities.
- The purpose of the FEL strategic review is to develop:
  - a 15 – 20 year vision for UK FEL science;
  - a 7 year strategy for FEL access, UK FEL facility provision, community development, and underpinning technology/skills.
- The major focus of the review will be X-rays, but it will also examine the UK community's needs for lower energy machines and incorporate this into the strategy. The UK has committed to becoming a full member of the European XFEL facility (now under construction near Hamburg, Germany), and so this review will provide the framework for making decisions on any further FEL commitments the UK may make.

# Extracts from FEL Review Terms of Reference

- This strategy will:
  - ...
  - identify the requirements for any underpinning technology or skills / capability needs noting where such development may also be important for other types of facility.
- This document will provide a basis for shaping future support for FEL science, FEL facility provision, and any long term technology developments in areas such as accelerators and instrumentation.
- Building on the outcome of the 2013 Programmatic Review and the direction already established within STFC of participation in XFEL and CLARA, examine the long term key science challenges that require FEL access based on inputs from the UK Research Councils, the UK science community via relevant STFC advisory panels and user groups, industrial stakeholders, and relevant facility directors.
- Identify means for meeting the UK's FEL access requirements. This includes:
  - ...
  - identifying any technologies that need to be developed in areas such as accelerators, detectors or instrumentation or skills that need to be maintained in the UK in order to underpin future UK FEL science.

# FEL Strategic Review

- Review still not complete
- But, basic conclusions don't seem to be changing:
  - Compelling argument for UK to invest in FEL science
  - The user community needs to be developed, primarily on EuXFEL
  - Capability in key areas of underpinning technology needs to be developed, including prototyping work at CLARA
  - There will be a need for a UKFEL in the future – probably an enhanced SwissFEL like facility (normal conducting RF, hard X-ray, ~6GeV, 100 Hz)
  - Exact specification in 5 years time

# Light Sources

- We have identified an accelerator-driven Free Electron Laser light source as our highest priority for a new accelerator based facility
  - Ultra-bright, coherent x-rays
  - UK participation in the European XFEL in Hamburg as a first step towards a UK FEL
  - CLARA as a technology testbed and development platform
  - Collaboration with SwissFEL
- Complemented by a Diamond Lattice upgrade to maintain the competitiveness of our national light source



# Priorities

- Maximally exploit our existing investments through accelerator upgrades to maintain the cutting edge (LHC, ISIS, Diamond...)
- An RF accelerator based FEL is our highest priority for a new accelerator based facility
- Require R&D investments and dedicated facilities (CLARA, FETS, MICE) to help to develop and make decisions
- ESS and XFEL are very important new UK commitments but not much scope for involvement in their accelerators
- Place is a consideration – Daresbury is key location for accelerator R&D
- If had to choose between R&D for a European facility and UK-based facility, would prioritise UK-based



# CLARA

*Compact Linear Accelerator for Research and Applications*

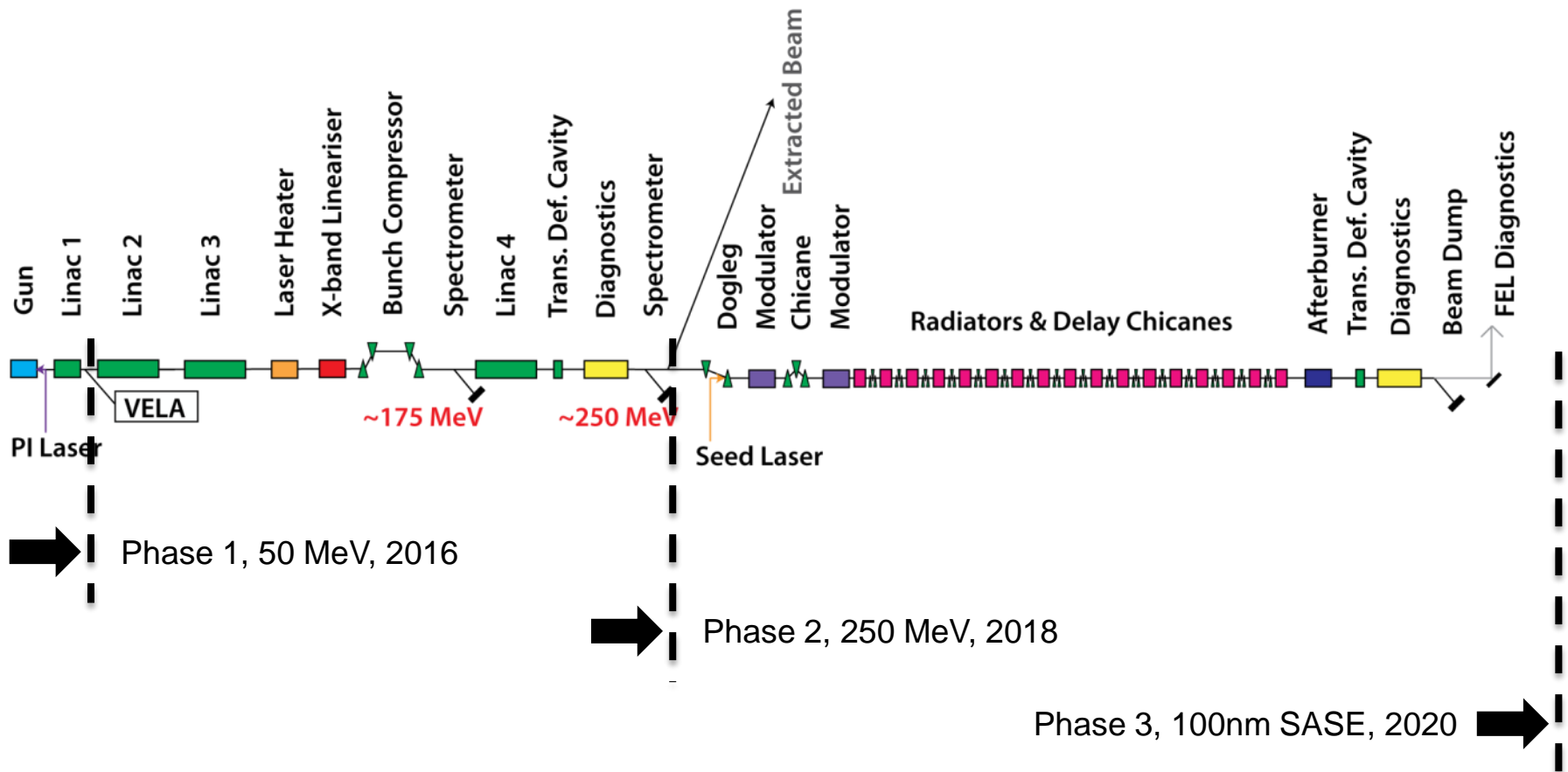
*An upgrade of the existing VELA Photoinjector Facility at Daresbury Laboratory to a 250MeV Free-Electron Laser Test Facility*

***Proof-of-principle demonstrations of novel FEL concepts and development of future accelerator technologies***

*Emphasis on **Stability, Synchronisation and new FEL capabilities***

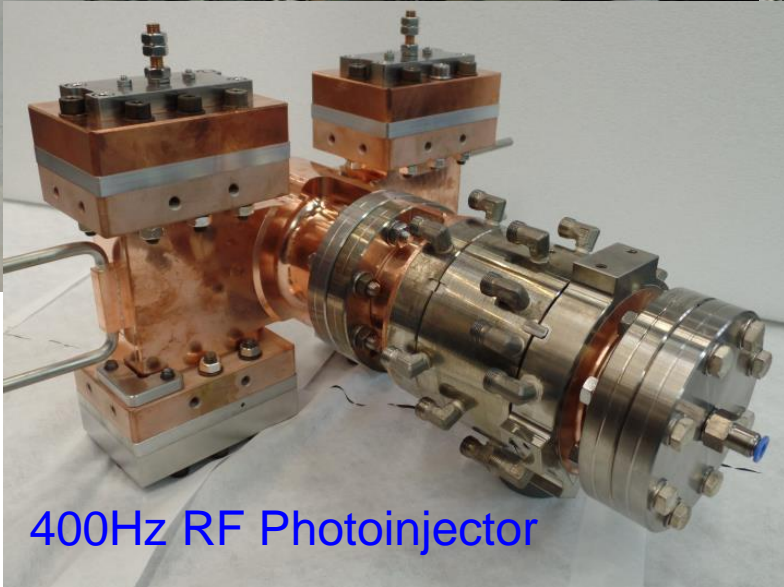
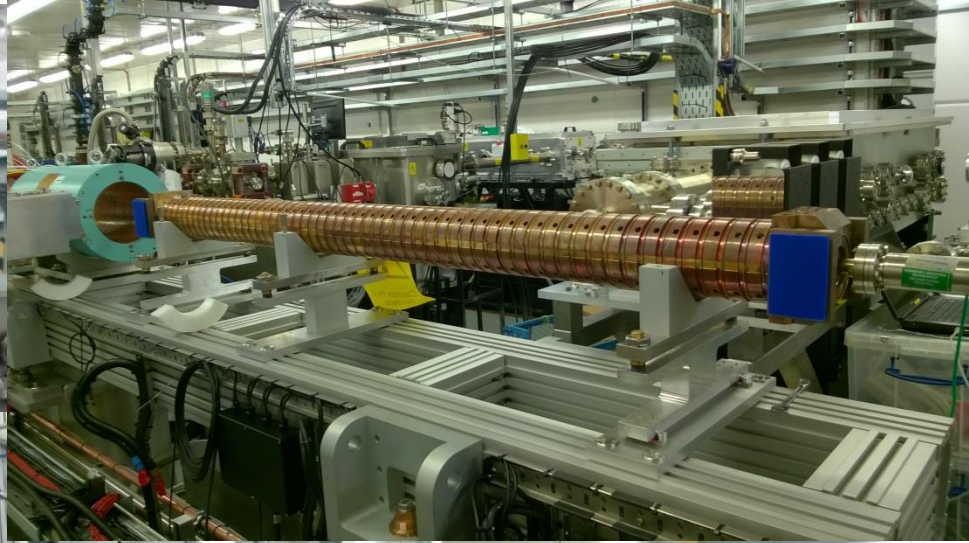


# CLARA Schematic & Project Phases





# CLARA Phase 1



400Hz RF Photoinjector



Commissioning starts Sept 2016

# UK X-FEL R&D Planning

- The accelerator community is generating a UK FEL R&D programme to develop the skills and technology required so that when we get the green light for the UK X-ray FEL facility we are ready to make well informed decisions on layout and have solutions to all major technical issues
- The plan has received input from ASTeC, CI, DLS, & JAI
- The six goals identified will need to be confirmed after the STFC FEL strategy is published and digested
- The heart of the R&D programme will be the detailed design, assembly, commissioning, development, and exploitation of the **CLARA FEL Test Facility**
- A very important aspect of the overall programme will be strong connections to the potential FEL user community.

# Agreed FEL R&D Goals

*Colour coded to highlight where **CLARA is impacting** on achieving these goals*

## #1: Gun development

Optimised electron source:

- designs for minimum emittance at low charge, minimum emittance at high charge etc.

## #2: RF

- RF frequency choice
- Low level and high level RF control and stability
- RF structure design & optimisation
- Economic optimisation of accelerating gradient
- Multibunch operation

## #3: Electron Beam Transport Simulation and Optimization

Delivering appropriate quality electron bunches at the entrance to the FEL and transporting through the FEL:

- Start to end simulations from cathode to FEL, optimizing performance and stability
- Understanding and mitigating (or potentially exploiting) collective effects such as space charge, wakefields, and CSR
- Alignment and tuning strategies within the FEL
- Beam switching between FELs (slow and fast)

# Agreed FEL R&D Goals

## #4: FEL Output Simulation and Optimization

Critically examine potential FEL output performance enhancements over current generation of X-ray FELs:

- Achieving the best FEL output stability shot to shot (intensity and wavelength).
- Generation of flexible FEL output pulse structures (eg two colour, two pulse, ...).
- Generating ultra-short photon pulses (sub fs).
- Generating transform limited FEL output (time-bandwidth product).
- Other potential enhancements (higher peak power, generating useful high harmonics of fundamental, polarisation control, ...)

## #5: Electron & Photon Diagnostics

- Bunch (slice) measurements at all charge levels
- Transverse and longitudinal profiles (e.g. cSPR, ...)
- Diagnostic for ultra-low charge operation, (cavity BPM)
- Feedback systems (trajectory, optics, energy, charge, ...)
- FEL pulse wavelength, pulse length, profile, etc.

## #6: Synchronisation

Achieving sub-10 fs synchronisation between the FEL output and an external laser:

- Timing distribution and synchronisation of essential systems.
- Measuring synchronisation level between FEL output and external laser.
- Measuring electron bunch arrival time.
- Minimising electron bunch jitter through passive or active schemes.

# Summary

- The STFC aspiration for a UK X-FEL is clear
- The accelerator and FEL community has agreed a number of FEL R&D goals
  - Gun development
  - RF Issues
  - Electron Beam Transport Simulation and Optimization
  - FEL Output Simulation and Optimization
  - Electron & Photon Diagnostics
  - Synchronisation
- CLARA will be at the heart of the FEL R&D programme
  - Front End commissioning soon
  - Procurement of remaining items for CLARA is ongoing
  - First lasing in 2020
  - We would like to test X band linac as well as X band lineariser (and maybe X band transverse deflecting cavity also) – we would need some help to be able to do this!